Observational and Modelling Studies of the California Current Mesoscale

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LONG-TERM GOALS

Our long-term goal is to describe, model, and predict the California Current mesoscale through analysis of observations and through modelling.

OBJECTIVES

Our scientific objectives are to use measurements from the Eastern Boundary Currents (EBC) field experiment and a quasigeostrophic (QG) model to describe and predict the dynamical balances of nonlinear eddies observed in the California Current System (CCS).

APPROACH

The observations consist of currents and temperatures measured in the upper 600 meters in the California Current System on eddy-resolving scales from current meter moorings deployed in three Local Dynamics Arrays (LDAs). Each LDA consisted of five moorings: four moorings forming a square around a central mooring, with instruments located at 100, 150, 300, and 600 meters depth. Mooring separation was about 15 km. These arrays were deployed off of Point Arena, CA. The first array was centered on the continental slope, the second one was in deep water adjacent to the slope LDA, and the third LDA was approximately 400 km offshore. Collaborators on the California Current Moored Array (CCMA) are M. Morris, R. Smith, M. Kosro, S. Ramp, and C. Collins. Additionally, a full ocean depth suite of hydrographic and nutrient measurements were made during the passage of a very strong eddy through the offshore LDA. D. Musgrave (hydrographic measurements) and B. Cornuelle (QG model) have collaborated with us on a detailed modelling study of this eddy, including dynamical balances and a description of its source waters.

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WORK COMPLETED

We have completed a study of the spatial and temporal characteristics of the California Current mesoscale based on analyses of the LDA moored time series (Chereskin et al., 1998). Our description includes an examination of dynamical balances, such as the balance of vorticity and divergence estimated across the arrays. Figure 1 shows the 2-year time series of vorticity and divergence at 150 m depth at the offshore LDA. Equally important, our estimates (based on linear least squares fits to horizontal velocity gradients) include error estimates, and the method is documented in an appendix of the manuscript. Divergence was never statistically different from zero, but the pulses of clockwise relative vorticity associated with 2 deep warm anticyclones that propagated across the array were about 30% of the local planetary vorticity and were statistically significant (Fig. 1). We also completed an observational and QG modelling study of a very strong, deep warm anticyclone (the May pulse in Fig. 1) that was well-documented by both shipboard hydrography and moored estimates (Cornuelle et al., 1998). For this eddy, the model provides a “dynamical interpolation” of the observations over both space and time from the hindcast, and a forecast that has significant skill for about 20 days of evolution.

RESULTS

There were several new results. The first is our documentation of the decrease in eddy abundance as one moves west from the coast. Although many eddies form at the coast, the eddies do not appear to fill the CCS in a dense, compact form from the coast out to 128°W - there appear to be large spaces between them as one moves offshore. However, there are at least some eddies generated at the coast that reach 128°W, and these include nonlinear anticyclones that trap anomalous fluid from the California Undercurrent (CUC) at depths of about 150-200 m, the core depth of the CUC. These eddies may play a particularly important role in transport and mixing since they transport fluid and properties in a direction that is orthogonal to the meridionally-oriented mean flows along the eastern boundary, and they appear to be quite long-lived.

IMPACT/APPLICATIONS

These results have revised our view of the CCS that formed our hypothesis for the EBC experiment. Rather than viewing the entire CCS as filled with mesoscale eddies, we now have a view of many eddies being formed at the coast, some of which dissipate in place, and some of which propagate west through the CCS to the N. Pacific Ocean.

TRANSITIONS

The analyzed mooring data have been used by Dr. Bruce Cornuelle in a QG modelling effort supported by NASA. In fact, the transition has been 2-way in that the data provided the initialization and the verification of the model physics for the region, and the QG modelling effort has enhanced our interpretation of the eddy dynamics (Cornuelle et al., 1998).

RELATED PROJECTS

This project is related to an NSF funded project in the NE Pacific: P17N, a WOCE hydrographic/ADCP/tracer transect that sampled past the moored array during the passage of a CUC

eddy. The hydrographic survey supplied nutrient and tracer data which unambiguously identified the water transported by the eddy as being equatorial in origin, transported northward by the CUC.

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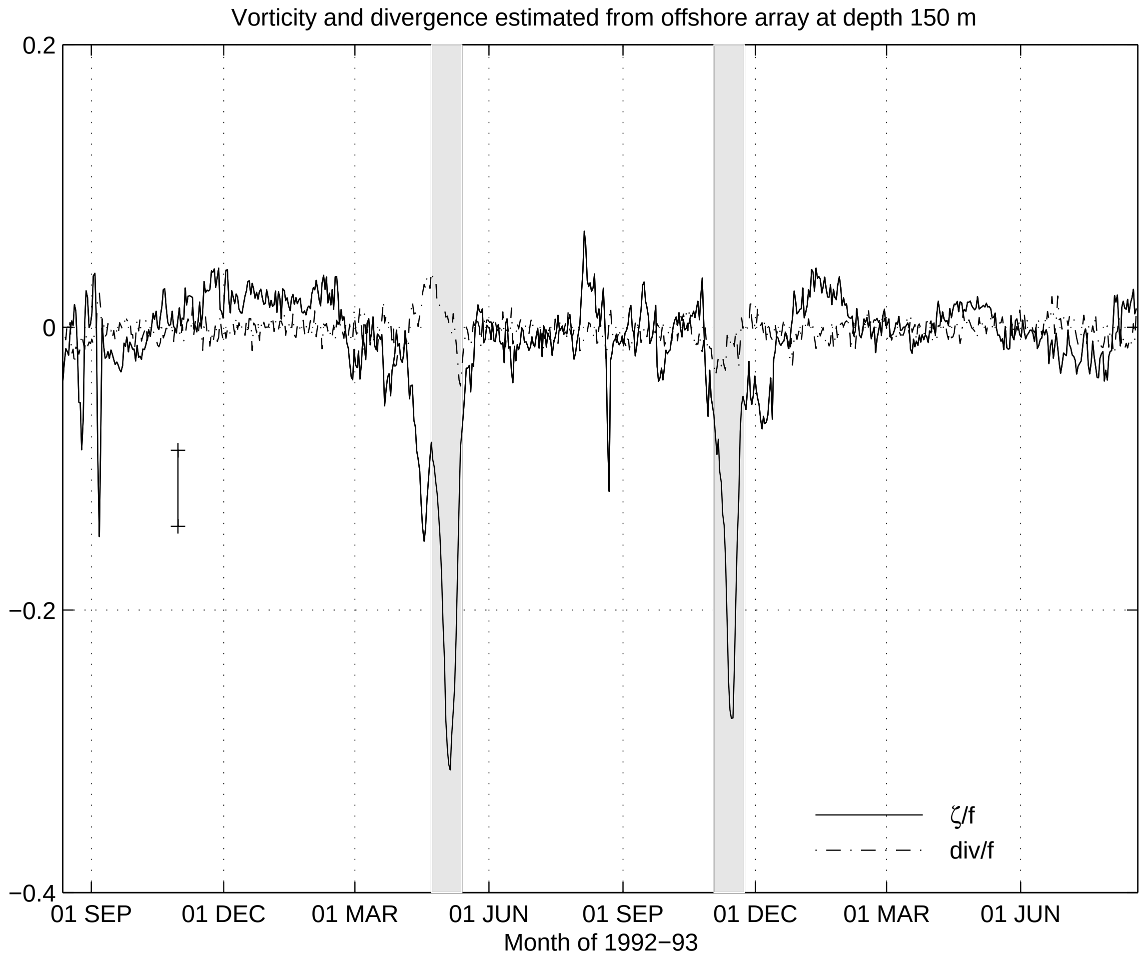

Figure 1. Horizontal divergence (dash-dot) and relative vorticity (solid) normalized by local planetary vorticity f. Shaded intervals correspond to the passage of deep warm anticyclones across the offshore LDA. Estimates were made across the array using linear least squares fits for the horizontal velocity gradients, centered on the array center, at a depth of 150 m. The error bar on vorticity and divergence (shown above) was computed using the uncertainty in the velocity gradient estimates. The uncertainty in the gradient estimates depended on the number of moorings, the array geometry, and the assumed noise covariance (20% of the signal covariance). To estimate uncertainty in vorticity and divergence, we treated them as the sum of 2 independent random variables since they are each the sum of 2 orthogonal gradient terms.